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Outplanting performance of western redcedar, yellow-cedar and Douglas-fir in montane alternative silvicultural systems (MASS)

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Strategic Importance

Reforestation of coastal montane and sub-alpine sites is frequently supplemented with plantings of commercially valuable and productive conifer species that were absent from or only a minor component of the pre-harvest stand. In the past, regeneration performance has often been unsatisfactory when species' ecological attributes were not suited to the climatic conditions of high-elevation clearcuts (Klinka and Pendl 1976). Little is known about how alternative non-dominant species will perform under retention silviculture systems recently implemented in coastal British Columbia. Varying the amount and density of overstorey retention may have long-term effects on regeneration performance, depending on species-specific ecological attributes (Klinka and Feller 1984), including shade tolerance and adaptation to a coastal montane climate characterized by short growing seasons and deep winter snowpack.

Western redcedar (*Thuja plicata* [Donn ex D. Don]), yellow-cedar (*Chamaecyparis nootkatensis* [D. Don] Spach) and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) are commercially valuable species variably to infrequently distributed in coastal montane forests dominated by western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and amabilis fir (*Abies amabilis* Dougl. Ex Forbes). The species range from very shade tolerant (western redcedar) and moderately shade tolerant (yellow-cedar) to relatively shade intolerant (Douglas-fir) (Krajina et al 1982). They also differ in their natural elevational distribution, with yellow-cedar occurring at higher elevations than western redcedar or Douglas-fir.

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Island to test alternative silvicultural approaches for regeneration that retain different patterns and densities of overstorey trees. The range of overstorey removal tested provides a wide range of light, temperature (air and soil) and to a lesser extent soil moisture, all of which can affect conifer productivity. In 1994, western redcedar, yellow-cedar and Douglas-fir container stock (1+0 313) was planted at the MASS site to compare outplanting performance in shelterwood (high-density dispersed retention), patch cut (aggregated retention), green tree (low-density dispersed retention) and conventional clearcut silvicultural systems. Each silvicultural system was applied to three replicated 9-ha treatment blocks. Six hundred seedlings of each species were planted in oval, 22-m-wide corridors in each of the three replicate treatment blocks of the four silvicultural systems.

Study site

Located in the Montane Moist Maritime variant of the Coastal Western Hemlock Zone (CWHmm[2]), the MASS site ranges in elevation from 740 m to 850 m. Climate is characterized by cool temperatures (5.4°C annual mean), a short growing season (150 frost-free days) and snow cover (<130 cm) for five months of the year. The pre-harvest stand was an uneven-aged, old-growth forest dominated by western hemlock (44% of basal area) and amabilis fir (24% of basal area), with varying amounts of western redcedar and yellow-cedar.

Results

Survival

After 10 years, western redcedar and yellow-cedar survival averaged 87% and 88%, respectively, and was comparable to that of western hemlock and amabilis fir from a related study of dominant regeneration on the same site (Figure 1). Douglas-fir had the lowest survival (68% to 71%) across all silvicultural systems. Poor morphological adaptation of Douglas-fir to high-elevation environments, including wider spreading branches that accumulate more snow, is known to increase stem breakage under heavy snow pack conditions, and likely

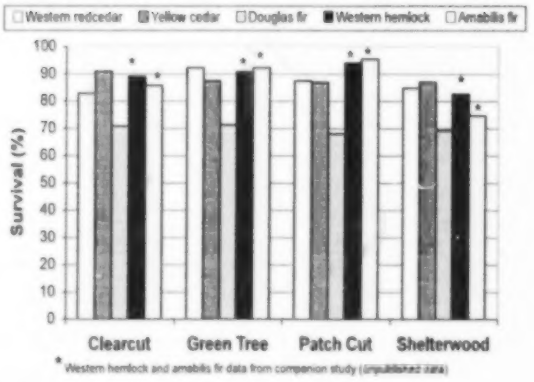

Figure 1. Survival of alternative and dominant conifer species after 10 years in clearcut and retention silviculture systems.

contributed to poor survival. The range of overstorey retention levels represented by the four silvicultural systems had little effect on survival of the three alternative species.

Growth response to silvicultural systems

Height growth was similar among the clearcut, green tree, and patch cut systems in both western redcedar and Douglas-fir (Figure 2). Although not statistically significant, yellow-cedar mean height in the green tree and patch cut systems was greater than in the clearcut.

Ten-year height in the shelterwood was reduced by 32% to 38% in western redcedar, and by 12% to 23% in yellow-cedar compared to the other silvicultural systems. Low understorey light levels resulting from a high density of dispersed overstorey retention (25%) is the primary factor limiting growth in the shelterwood. In contrast, the relatively shade-intolerant Douglas-fir showed little decrease in height growth in response to overstorey shading in the shelterwood, although its diameter growth (not shown) showed a proportionately larger decrease.

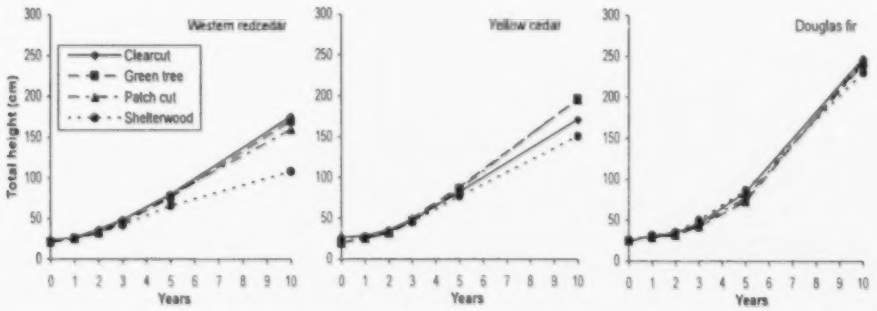

Figure 2. Ten-year height growth of western redcedar, yellow-cedar and Douglas-fir in clearcut and alternative silviculture systems.

Species comparisons

Douglas-fir height after 10 years was greater than that of western redcedar or yellow-cedar in all silvicultural systems, although Douglas-fir was only significantly larger than yellow-cedar in the clearcut and shelterwood (Figure 3). Douglas-fir height averaged over all silvicultural systems was 36% and 58% greater than that of yellow-cedar and western redcedar respectively.

Yellow-cedar height tended to be greater than that of western redcedar, except in the clearcut where the two species were similar in height. Slower growth of western redcedar is likely a function of poor adaptation of this species to montane climates. In the reduced-light environment of the shelterwood, differences in species' shade tolerance had relatively little effect on growth. While height growth in the shelterwood was reduced in absolute terms in all species, relative differences between species were generally unchanged except for western hemlock which showed the largest decline in height.

Comparison with results from the companion study of dominant conifers indicate that, after 10 years, western hemlock is more productive than Douglas-fir in the clearcut, patch cut and green tree systems, while growth of amabilis fir is generally intermediate between western redcedar and yellow-cedar (Figure 3).

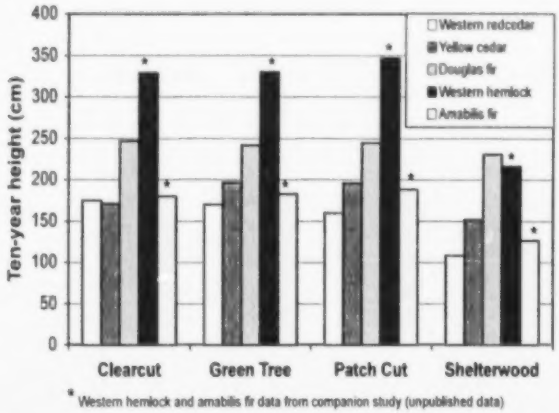

Figure 3. Height of alternative and dominant conifer species after 10 years in clearcut and retention silviculture systems.

Form defects

The incidence of stem deformities from dead, broken, browsed and forked tops in western redcedar, yellow-cedar and Douglas-fir ranged between 7% and 22% (Figure 4), and were at acceptable levels (< 20%) in the clearcut, green tree and shelterwood according to criteria used by Scagel et. al. (1989). Stem deformities in Douglas-fir and yellow-cedar tended to be highest in the patch cut and clearcut. Due to the higher proportion of dead tops in western redcedar at the time of planting, post-planting stem deformities in this species are probably less than that reported. The incidence of stem deformities tended to be higher in the three non-dominant species than in the dominant species on the site, particularly amabilis fir in which stem deformities on average were present in only 6% of live trees.

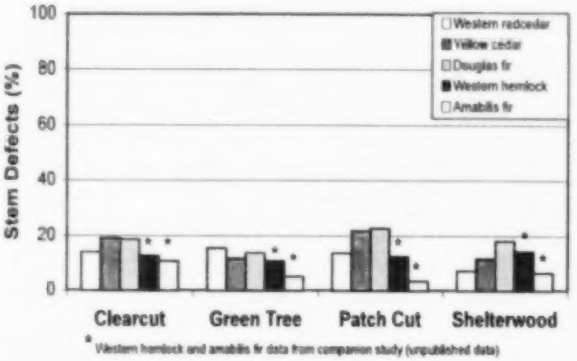

Figure 4. Stem defects in conifers planted in clearcut and retention silviculture systems

Management Implications

- Compared to the clearcut treatment, similar (western redcedar, Douglas-fir) or better (yellow-cedar) height growth in the green tree and patch cut treatments after 10 years supports the view that low-density dispersed and aggregated retention systems can be implemented on coastal montane sites without reducing early plantation performance (Mitchell et al 2004).
- Douglas-fir and western redcedar—low-elevation species—exhibited marginal performance throughout the range of overstorey retention treatments. Douglas-fir growth was good but survival (70%) was below acceptable levels—confirming earlier reports that this species is usually a poor choice for restocking high-elevation sites (Klinka and Pendl 1976). Western redcedar had the lowest growth of all species tested, including the dominant species on the site. Although it often forms a minor component in coastal montane forests, western redcedar regeneration is susceptible to frost (Scagel et al.1989). These results support Arnott et al.'s conclusions (1995) that planting of Douglas-fir and western redcedar should be restricted to the lower-elevational limits of the CWH.

- Yellow-cedar, a commercially valuable species, exhibited good survival and acceptable growth— particularly in the green tree and patch cut treatments. Yellow-cedar height tended to be greater than that of western redcedar, but less than that of Douglas-fir. While other studies have reported yellow-cedar to be productive, it has been described as an "enigmatic" species, prone to form abnormalities and variable performance on subalpine sites (Scagel et al 1989). These early results indicate that on montane sites in the CWH, where winters are less severe, yellow-cedar performance may be more reliable.
- Western hemlock, a dominant species on this site, was more productive than the three alternative species in all silvicultural systems except the shelterwood, where Douglas-fir showed similar growth. Although superior growth and good survival indicate that western hemlock is a preferred species for restocking of montane sites, Arnott et al (1995) reported a high frequency of form defects in this species at higher-elevational limits of the montane CWH. The other dominant species, amabilis fir, had relatively slow growth, but the incidence of stem deformities was the lowest of all the species studied, making it a more reliable candidate for restocking.
- None of the species studied were well suited to high levels (25%) of dispersed overstorey retention in the shelterwood. Low understorey light was the main factor responsible for poorer growth in the shelterwood, and suggests that a lower density of dispersed retention or grouped shelterwood would allow more understorey light for regeneration. Vigorous shrub competition in the shelterwood may have also contributed to poorer growth.
- As outplanting performance can vary widely with site conditions at high elevations (Burgess et al 2003), these results should not be extrapolated to other coastal montane sites without matching species-specific ecological attributes to site-specific climatic, physical and edaphic conditions (Klinka and Feller 1984).

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Additional Reading

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